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AUTHORITY

US Naval Construction Battalion Center ltr dtd 24 Oct 1974

PROTECTIVE SHELTER SYSTEMS: AN ANNOTATED BIBLIOGRAPHY OF U. S. NAVAL CIVIL ENGINEERING LABORATORY PUBLICATIONS

TN - 562

28 February 1964

U. S. Naval Civil Engineering
Laboratory
Port Hueneme, California

(5) Naval Civil Engineering Lab., Port Hueneme, Calif.

(6) PROTECTIVE SHELTER SYSTEMS: AN ANNOTATED BIBLIOGRAPHY OF U. S. NAVAL CIVIL ENGINEERING LABORATORY PUBLICATIONS,

(16) Proj. Y-F008-08-02-118

Type C

(10) by

R. H. Seabold,

ABSTRACT

This annotated bibliography lists publications by the U. S. Naval Civil Engineering Laboratory on atomic, biological, and chemical protective shelter, and on the testing of mechanical equipment and advanced base buildings which could be adapted for shelter use. Classified references are listed; unclassified references are listed and annotated. The references are grouped with regard to their subjects. Within these groups, they are arranged in chronological order.

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INTRODUCTION

This annotated bibliography lists publications by the U. S. Naval Civil Engineering Laboratory on atomic, biological, and chemical protective shelter, and on the testing of mechanical equipment and advanced base buildings which could be adapted for shelter use. Classified references are listed; unclassified references are listed and annotated.

The references include technical reports (TR), technical compilations (TC), technical memoranda (TM), technical notes (TN), contract reports (NBy and NOy), symposia (Sym), and weapons test reports (WT). The weapons test reports listed herein were written by personnel at the Laboratory for Headquarters Field Command, Defense Atomic Support Agency.

The following information is given for each reference: publication number or contract number, task number, title, author, date, number of pages, classification, and abstract. If no classification is given, the reference is unclassified. Where possible, the abstract gives the objective, materials used, procedure, and results of the work reported.

The references are grouped with regard to their subjects. Within these groups, they are arranged in chronological order.

1. GENERAL SHELTER INFORMATION

TN-082 NY 340 004-1
METHODS OF CONCEALMENT USED FOR SHORE ESTABLISHMENT DEFENSE, W. A. Bowen, Jr., 15 Mar 52, 10 pp.

Concealment as a passive defensive measure presupposed the existence of detection devices controlled by the enemy. These detection devices may take one of many forms such as visual, photographic, radar, television, infrared, gravitational, magnetic, electrostatic, or chemical. The methods of concealment from these detection devices include Jamming, Window, Harp, Ionic Barriers, Photo-electric Emission, and Screens. The screens are large sprays of sea water, sprinklers installed along top edges of tall structures, reflecting metallic screens, and absorbing metallic screens.

NOy-28151
A STUDY OF THE PASSIVE DEFENSE OF SHORE INSTALLATIONS, v. 1: THE CHARACTERISTICS OF AERIAL GUIDANCE MOST LIKELY TO BE USED AGAINST SHORE TARGETS, v. 2: EXISTING AND PROPOSED MEANS OF PASSIVE DEFENSE FOR USE WITH SHORE TARGETS, University of Colorado, May 53, SECRET.

TN-148 NY 340 004-1
PRINCIPLES OF INFRARED CAMOUFLAGE FOR LOW TEMPERATURE TARGETS, W. L. Starr, E. R. Streed, and A. I. Funai, Jul 53, CONFIDENTIAL.

NBy-3188
GUIDEBOOK FOR THE PLANNING OF INTEGRATED ATOMIC DEFENSE SHELTERS IN SELECTED MILITARY BUILDING TYPES, G. H. Albright, A. F. Dill, R. O. Enge, et al., Shelter Research and Study Program, College of Engineering and Architecture, The Pennsylvania State University, University Park, Pa., 15 Feb 61, 194 pp., 214 Illus..

This guidebook presents information to architects and planners for effectively planning integrated shelters as part of the design of selected military building types. The principles of protection, the philosophy of integrated convertible shelters, weapons effects, and architectural planning considerations are presented as background for the planning analyses of the integrated convertible shelters presented for several selected military building types.

TR-128 Y-F011-05-401(A)
SUBMARINE HULKS AS PROTECTIVE SHELTERS, R. F. Swalley, 21 Feb 61, 27 pp.

A feasibility study of using obsolete SS-212 (GATO) class submarine hulks as personnel shelters is presented. Modifications of the submarine for it to function as a shelter are discussed. Various schemes were considered for emplacing it underground. It was estimated that a submarine hulk could be adequately modified and emplaced for about $60,000.

2. ARCHITECTURAL DESIGN AND PLANNING

2.1 Entranceway Design

NBy-3163
DESIGN OF ENTRANCEWAY SYSTEMS FOR PERSONNEL PROTECTIVE SHELTERS, Armour Research Foundation of Illinois Institute of Technology, Chicago, Illinois, Dec 59, SECRET.

TN-423 Y-F011-05-401(d)
APPLICATION OF QUEUEING THEORY TO THE DESIGN AND LOCATION OF PERSONNEL SHELTERS, J. R. Kettenring, Jun 62, 32 pp.

Techniques were developed, by the application of queueing theory, for determining whether a given shelter location, passageway design, and entranceway width will permit all assigned personnel to enter safely within a specified time limit.

TN-472 Y-F011-05-401(d)
STUDY OF QUEUING THEORY IN SHELTER ENTRANCEWAY DESIGN, D. B. Ryder, 18 Jan 63, 39 pp.

Experimental data are presented which test the assumptions on which Technical Note N-432, "Application of Queueing Theory to the Design and Location of Personnel Shelters," is based. A method outlining the development of design criteria of general usefulness is given.

2.2 Habitability

TN-354 Y-F011-05-401(b)
SHELTER HABITABILITY STUDIES: THE EFFECT OF ODOR IN A SHELTER AND VENTILATION REQUIREMENTS, J. S. Muraoka, 22 Nov 60, 18 pp.

A literature search and studies were made of the effects of body and tobacco smoke odors on man, and of the ventilation requirements for the removal of these odors from enclosed structures.

TR-146 Y-F011-05-401(b)
SHELTER HABITABILITY STUDIES: ODORS AND REQUIREMENTS FOR VENTILATION, J. S. Muraoka, 8 May 61, 19 pp.

A literature survey was made to determine the tolerable limits of tobacco smoke and body odors in shelters, and to determine the ventilation requirements for the reduction of these odors.

TR-144 Y-F011-05-401(b)
SHELTER HABITABILITY STUDIES: THE EFFECT OF OXYGEN DEPLETION AND FIRE GASES ON OCCUPANTS OF SHELTERS, J. S. Muraoka, 18 Jul 61, 33 pp.

A literature survey was made to determine shelter habitability problem areas and tolerable limits of habitability parameters, and an evaluation was made of the effects of various gases on shelter occupancy.

3. BIOLOGICAL AND CHEMICAL WARFARE

TM-035 NY 300 01B-1
BUILDING PROTECTION AGAINST BIOLOGICAL WARFARE ATTACK, W. Viessman and E. N. Hellberg, 1 Feb 52, 19 pp.

Since results of tests conducted on a small temporary shelter indicated that it is practical to protect buildings from bacteriological and chemical attack by pressurizing the interiors with filtered air to provide outward flow of air at all leakage points, plans were formulated to evaluate the efficiency of BW and CW protective measures as applied to larger semi-permanent buildings. The frame building to be tested is described in this technical memorandum.

TM-074 NY 300 007-2
PROTECTION OF BUILDINGS AGAINST BIOLOGICAL WARFARE, W. Viessman, E. N. Hellberg, and H. M. Whippo, Jr., 10 Dec 53, 61 pp.

Pressurized filter plenums designed by the Bureau of Yards and Docks, the Chemical Corps E-35 collective protector, and the electrostatic precipitators developed by the Naval Research Laboratory were tested and evaluated. Personnel shower requisites were determined and techniques were developed. As part of the Bureau's program of slanting construction of buildings toward conversion to protective shelters in an emergency, a portable air lock with shower developed by BuDocks was tested, evaluated, and found satisfactory and practical. It was found practical to seal and pressurize a 50,000 cu ft frame building.

TM-107 NY 300 006-5 NY 300 006-2
CONSTRUCTION, PERFORMANCE, AND BW EVALUATION TESTS OF PORT HUENEME PRESSURIZED BUILDING, JANUARY 1955, E. N. Hellberg, 15 Oct 55, 21 pp.

Tests were conducted to determine whether changing the airflow pattern around a building will affect the penetration of BW aerosol agents, and to study the operation of an air lock system at building pressures of 0.2 and 0.05 inches of water.

TN-277 NY 300 010-1
VENTILATION SYSTEM PROTECTION AGAINST BW AEROSOLS, W. R. Nehlsen, 27 Jun 56, 7 pp.

Results showed that a high percentage of particles below three microns in diameter will penetrate an air conditioning system equipped with panel-type ventilation air filters.

TN-287 NY 300 010-1
ARRESTANCE, RESISTANCE, AND DUST-LOADING TESTS ON COMMERCIAL AIR FILTERS, E. N. Hellberg and W. R. Nehlsen, 1 Feb 57, 53 pp.

Commercial air filters were tested to determine their effectiveness in decontaminating ventilation air containing BW aerosols. The results indicated that commercial air filters are not suitable for BW defense, but may usefully serve as prefilters for special BW filters.

TN-297 NY 300 010
REVIEW OF DECONTAMINATION SHOW UNIT TESTS AND PLANS, W. R. Nehlsen, 13 Mar 57, 11 pp.

The objective of the project was to develop a portable decontamination shower unit for bacteriological warfare passive defense and for field use, and to investigate the possibility of recirculating waste shower water to conserve water supply. Good success with BW and radiological simulants was noted, but the unit was expensive and poor results on recirculation with CW agents were predicted by the Army Chemical Warfare Laboratory.

TM-127 NY 300 010-1
AEROSOL TRAVEL THROUGH VENTILATION SYSTEMS, E. N. Hellberg, 11 Jun 57, 83 pp.

Results are shown of a study of aerosol travel through both a high- and a low-velocity experimental ventilation system. Aerosol particles larger than 3 microns in diameter were removed to varying degrees by the ventilation system components while smaller particles essentially were unaffected.

TR-038 Y-F011-05-326
DEVELOPMENT OF AN IMPROVED CW IMPREGNATING PLANT, J. E. Halton, 7 Sep 59, 41 pp.

The report presents the development, fabrication, and testing of new chemical equipment to be used in conjunction with a portable laundry unit for impregnation purposes.

TR-072 Y-F011-05-250
ABC DECONTAMINATION EQUIPMENT FOR PERSONNEL IN THE ARCTIC, W. R. Nehlsen, 8 Mar 60, 17 pp.

A 60 man per hour portable shower unit was designed for decontamination of large numbers of personnel in arctic climates. A shower waste water treatment and recirculation system was included to minimize the effects of critical water shortages expected under arctic conditions. Tests showed that satisfactory results could be obtained on atomic and biological agents, but the allowable time interval before starting chemical agent decontamination proved to be so brief no mass decontamination method could be considered effective.

TR-156 Y-F011-08-327
STATISTICAL ANALYSIS OF SIX VENTILATION AIR FILTERS, E. N. Hellberg, 24 Jul 61, 19 pp., FOR OFFICIAL USE ONLY.

A statistical analysis was made of six different commercial air filters to determine the most promising for protective or decontamination applicability for BW-CW defense.

TR-229 Y-F011-08-203
CORROSION STUDIES ON BW-CW DECONTAMINANTS, C. V. Brouillette, 31 Apr 63, 53 pp.

The object of this task was to determine the corrosiveness of various BW-CW decontaminants toward the common metals of construction, such as steel, copper, aluminum, magnesium, and zinc, with emphasis placed on the metals and alloys used in the manufacture of high-speed aircraft. Standard decontaminants tested were (1) STB (super tropical bleach), (2) DANC (6-1/4 percent dichlorodimethylhydantoin in tetrachloroethane), (3) formalin, (4) beta-propiolactone, and (5) DS-2 (diethylenetriamine/methyl cellosolve/sodium hydroxide - 70/28/2). The corrosiveness of these decontaminants to 33 metals and alloys and seven metallic couples was determined by two types of tests; one by partial immersion, one by atmospheric exposure. In general the corrosive attack of the decontaminants on the metals was more severe in the immersion test than in the atmospheric-exposure test. The data indicate that DS-2 and beta-propiolactone are, in general, the least corrosive of the decontaminants evaluated.

4. THERMAL RADIATION

NOy-28146
DEVELOPMENT OF ARCTIC FIRE EXTINGUISHERS, Final Report, L. A. Roe, Bjorksten Research Laboratories, Inc., Madison, Wisconsin, Jun 52, 56 pp.

Tests with new fluorinated hydrocarbon liquid agents showed that these agents were effective on all types of fires under arctic conditions.

Sym-FERE
PROCEEDINGS OF THE SYMPOSIUM ON FIRE EXTINGUISHMENT RESEARCH AND ENGINEERING, Nov 54.

TM-108 NY 030 019-1
EVALUATION OF HALOGENATED HYDROCARBON AND ALKALI-EARTH-METAL-SALT FIRE EXTINGUISHING AGENTS FOR LOW TEMPERATURES, R. J. Zablodil, 1 Nov 55, 41 pp.

Four vaporizing halogenated-hydrocarbon-type and water-base alkali-earth-metal-salt-type extinguishing agents were tested on a NCEL standardized surface Class A fire.

TN-366 Y-F015-11-232
EFFECT OF SPRINKLER HEAD PARTICLE SIZES AND DISTRIBUTION ON FIRE EXTINGUISHMENT, R. J. Zablodil and R. S. Chapler, 17 Aug 59, 17 pp. FOR OFFICIAL USE ONLY.

In order to obtain maximum utilization from a limited supply of storage tank water of an NCEL developed advanced base packaged sprinkler system, certain commercially manufactured sprinkler heads were investigated to determine which produced particle sizes and distribution for superior extinguishment of a laboratory class A test fire.

TR-067 Y-F015-11-232 NY 000 013-8.03
A PACKAGED FIRE SPRINKLER SYSTEM FOR ADVANCED BASE BUILDINGS, R. J. Zablodil, C. R. Hoffman, and R. S. Chapler, 18 Feb 60, 35 pp.

A fire sprinkler system was developed to protect a standard 20 ft x 48 ft advanced base building. It has a 370 gal storage tank, a rectangular, 12-headed sprinkler loop, and associated valves and fittings. The system is dry and starts automatically when supervisory pressure maintained in the loop is lost. Pressure loss opens the pilot operated main nitrogen valve to pressurize the storage tank from two high pressure nitrogen cylinders.

TR-087 Y-R007-08-408
FIRE-RETARDANT COATINGS, R. L. Alumbaugh, 20 Oct 60, 27 pp.

NCEL investigated coatings and impregnates which are intended to protect wooden structures from fire. Weathering properties, fire-retardant characteristics and the relative effectiveness of three methods of testing their fire-retardant ability were studied. Fifteen fire-retardant systems applied to wooden test panels and exposed to a marine atmosphere were tested after four to eighteen months weathering. The fire-retardant characteristics of the majority of coating systems decreased as a result of weathering. However, one of the systems showed no evidence of coating failure, and its fire-retardant characteristics improved with weathering. Nine systems were tested for fire-retardant properties using three standard test methods. The National Bureau of Standards Radiant Panel Method and the ASTM Stick and Wick Method generally ranked the systems in the same order of effectiveness, while results of the ASTM Fire Test Cabinet Method showed some variation from this order. The NBS Radiant Panel Method differentiated between coating systems better than either ASTM method.

TR-089 Y-F015-15-105
EFFECTS OF JET-ENGINE EXHAUST ON VIRGINIA DIABASE CONCRETE PAVEMENT, H. Tomita, 14 Nov 60, 24 pp.

NCEL conducted a study to determine the resistance of Virginia deabase concrete to thermal shock from jet aircraft operations.

TR-132 Y-R007-08-903
FIRE EXTINGUISHERS CONTAINING INHIBITED LITHIUM CHLORIDE SOLUTION FOR POLAR USE, C. V. Brouillette, 27 Mar 61, 17 pp., FOR OFFICIAL USE ONLY.

Five different commercial extinguishers, fabricated of drawn brass or silicon bronze and lined with a lead alloy, were tested with the lithium chloride solution using either sodium dichromate-oxalic acid or sodium dichromate alone as an inhibitor.

TR-150 Y-F011-05-401(c)
PROTECTION OF EXPOSED PARTS OF SHELTERS AGAINST THERMAL RADIATION FROM MEGATON WEAPONS, F. W. Brown, III and A. Y. Eliason, 28 Jul 61, 19 pp.

A theoretical study was made to determine the effects on the exposed parts of underground shelters of thermal radiation from the explosion of nuclear weapons. Simple carbon and graphite shields are discussed, and more sophisticated shielding systems are proposed for future experimental studies.

TR-165 Y-F011-05-334
A FENESTRAL SPRINKLER SYSTEM TO PREVENT FIRES CAUSED BY THERMAL RADIATION, J. C. King, 14 Sep 61, 15 pp.

A fenestral sprinkler system was designed to extinguish fires which can result from the entrance through windows of thermal radiation from a nuclear explosion.

TR-170 Y-F015-15-106
EFFECT OF AGGREGATE SIZE ON THERMAL SHOCK RESISTANCE, H. Tomita and D. B. Taylor, 6 Nov 61, 27 pp.

A study was made to determine if the size of the aggregate used in a concrete mix is a contributing factor to the explosive spalling that takes place when concrete pavement surfaces are subjected to the thermal shock of turbojet engine exhaust.

TN-442 Y-F011-05-401(c)
IGNITION OF FIRES AND FIRE SPREAD BY THERMAL RADIATION, F. W. Brown, III., 25 Jun 62, 22 pp.

This technical note discusses the primary and secondary fires resulting from a nuclear weapon explosion, the relationship between the incidents of secondary fires and earthquake-produced fires in the United States, and the relationships between the area destroyed by fire and blast as a function of yield. It is concluded in the report that the ratio of fire damage area to the blast damage area increases with the yield of the weapon. Primary fire will be a significant factor and the elimination of potential fire sources is of the utmost importance. The probability that a fire storm can be prevented by the use of adequate firebreaks augmented by the use of fire retardant paint is discussed.

TR-211 Y-F011-01-043
PROTECTION AGAINST INTENSE THERMAL RADIATION (A Device for Automatically Closing Venetian Blinds), J. C. King, 27 Jul 62, 18 pp.

A device was developed for automatically closing venetian blinds to prevent the entrance of thermal radiation through windows. The device may be triggered by the flash of a nuclear explosion or by a central manually operated switch.

5. NUCLEAR RADIATION

5.1 General

TN-005 YD-320-1
MOBILE RADIOLOGICAL FIELD LABORATORY, J. J. Newman, 25 Jan 51, 19 pp.

A Mobile Radiological Field Laboratory received from the Chief Signal Officer, Department of the Army was given a preliminary evaluation. The unit was found to be adequate for its intended purpose, but the absence of spare parts and operating instructions made it unsatisfactory at that time.

NBy-3169 (AD-112)
OUTLINE OF A SHIELDING MANUAL FOR PROTECTIVE CONSTRUCTION, A. G. Duneer, M. J. Kelly, and L. B. Mendelsohn, Associated Nucleonics, Inc., 975 Stewart Avenue, Garden City, N. Y., Dec 58, 33 pp.

This report covers preliminary work necessary for the development of a radiation shielding manual for protective construction; the manual is to provide adequate information for the ready design of bomb shelters by personnel not trained in the nuclear field.

TR-083 Y-F011-05-401
RADIATION SLIDE RULE FOR ATOMIC FALLOUT PROBLEMS, J. C. LeDoux, 24 May 60, 27 pp.

This report presents the theory, construction, and use of a circular slide rule which is designed to solve passive defense problems dealing with residual radiation. The rule is based on the $t^{-1.2}$ law of radioactive decay. The slide rule can be used to solve an infinite number of individual problems without the necessity of interpolation in tables or construction of graphic plots. A number of typical problems are worked with the slide rule to indicate its method of use.

TN-385 Y-F011-05-329
PROGRESS IN RADIATION SHIELDING RESEARCH FOR PROTECTIVE SHELTERS, A. B. Chilton, 23 Jun 60, 83 pp.

The status of radiation shielding technology is discussed, with particular emphasis on protection against radiation resulting from nuclear weapons explosions. The exposition, oriented toward an audience of civil engineers, describes the basic concepts and presents brief descriptions of important research work carried out in various institutions in the United States. An extensive list of source material is provided.

TC-003 Y-F011-05-401
COMPILATION OF EXPONENTIAL FUNCTIONS FOR ARGUMENTS FROM 2 THROUGH 50, J. C. LeDoux and L. K. Donovan, 25 Jul 60, 109 pp.

Exponential functions are required for expressing mathematically the attenuation of nuclear radiation through various materials. This compilation provides functions

$$e^{-x}, \quad \frac{e^{-x}}{x}, \quad E_1(x), \quad \frac{F(x)}{x}, \text{ and } xe^{x}E_1(x)$$

for arguments from 2.00 to 50.99 with a maximum error of $\pm$ 3 in the sixth significant figure.

TN-389 Y-F011-05-402
DETERMINATION OF PARAMETERS IN AN EMPIRICAL FUNCTION FOR BUILD-UP FACTORS FOR VARIOUS PHOTON ENERGIES, A. B. Chilton, D. Holoviak, and L. K. Donovan, Aug 60, 12 pp.

A development is presented of mathematical formulae, graphs, and tables based on available scientific data on nuclear shielding for inclusion in a shielding manual on nuclear defense construction. In the computation of gamma-ray attenuation, it is desired to use a simple expression for build-up factors. In this development, a simple analytical expression was used for Dose Build-up Factors from a radioactive isotropic point source. The parameters of the expression were determined by the method of least squares to obtain an optimum fit to experimental data for build-up factors for aluminum at various photon energies.

NBy-32190 (tech/ops TO-B61-39)
MONTE CARLO CALCULATIONS ON THE REFLECTION AND TRANSMISSION OF SCATTERED GAMMA RADIATIONS, Final Report (Revised), D. J. Raso, May 63, 78 pp.

Monte Carlo calculations were performed to determine the backscattering and the transmission of gamma rays having energies between 0.02 Mev and 10.0 Mev from concrete. The radiation was assumed to be incident on a semi-infinite medium and on various slab thicknesses of 0.5, 1.0, 2.0, and 4.0 mean free paths at angles of $\cos \theta_o$ = 1.0, 0.75, 0.50, 0.25, and 0.10. The case histories of 5000 photons were followed on the IBM 704 digital computer. The information obtained included: (1) the characteristics of emergent photons, (2) a routine that processes these characteristics to give polar and azimuthal angular dose distribution, and (3) detailed results from the application of the processing routine to the parameters investigated. The computer program, the processing routine, and the results are appended. This report supersedes a report with the same title dated July 1961.

5.2 Decontamination, Air Locks, and Recovery

TN-076
LAND RECLAMATION, OPERATION JANGLE, PROJECT 6.2, C. A. Leonard, Feb 52, SECRET.

TN-160 NY 300 010
PACKAGING OF FORMALDEHYDE FOR DECONTAMINATION, A. L. Fons, 13 Nov 53, 8 pp.

A study was made of the packaging and shipping of 40 percent aqueous formaldehyde solutions. The results of the study constituted the basis of formulation of minimul standards for packaging and shipping specifications of such solutions.

TN-281 NY 300 010-4
RADIOLOGICAL TEST OF DECONTAMINATION SHOWER WASTE WATER RECIRCULATION, W. R. Nehlsen, 4 Oct 56, 7 pp.

An experimental portable arctic decontamination shower unit was devised using sedimentation and chlorination as a basis of waste treatment. This system was tested with a radioactive fallout simulant at the U. S. Naval Radiological Defense Laboratory. Results indicated that over 99 percent of the simulant was removed from the waste water and was deposited in the shower sump and waste treatment tank. It was concluded that a waste water treatment and recirculation system should be included in the unit design.

TN-297 NY 300 010
REVIEW OF DECONTAMINATION SHOWER UNIT TESTS AND PLANS, W. R. Nehlsen, 13 Mar 57, 11 pp.

The abstract is presented on page 6.

NBy-3128
AIRFIELD VACUUM CLEANER DECONTAMINATION: FINAL ENGINEERING REPORT, J. T. Barnett, R. Schmidt, and E. H. Birdsall, Coleman Engineering Company, Inc., Torrance, Calif., 5 Jun 59, 46 pp.

This report summarizes the results of a study and testing program conducted to determine performance of selected procedures and equipment in dislodgement, pick-up, and retention of fall-out particles.

TN-376 Y-F011-05-203 NY 320 002-3
DECONTAMINATION OF PAVEMENTS BY MOTORIZED SWEEPERS: OPERATIONAL REQUIREMENTS, SWEEPER CHARACTERISTICS, AND DEVELOPMENT PROGRAM, W. R. Nehlsen, 23 Nov 59, 31 pp., FOR OFFICIAL USE ONLY.

This note presents results of a study of operational requirements for pavement decontamination, analysis of existing capabilities of sweepers, and selection of required developments to meet decontamination requirements.

TR-072 Y-F011-05-250
ABC DECONTAMINATION EQUIPMENT FOR PERSONNEL IN THE ARCTIC, W. R. Nehlsen, 8 Mar 60, 17 pp.

The abstract is presented on page 6.

TR-036 Y-F011-05-327
COMPARTMENT-TYPE AIR LOCK STUDIES, E. N. Hellberg, 28 Jun 60, 41 pp.

A portable prefabricated air lock for interior use was developed, and then compared with the Bureau of Yards and Docks standard portable air lock for exterior use. About sixty tests were performed to determine air lock performances. Most of the tests were conducted at a building pressure of 0.4 inches of water with air flows through the locks varying from 200 to 400 cfm. Both air locks performed satisfactorily when operated at 300 cfm. However, it was difficult and inconvenient to regulate the air flow through the perforated doors of the NCEL developed lock. The NCEL air lock was more easily assembled, disassembled, and stored. A final design incorporates the best features of the original NCEL lock and the BUDOCKS lock, and the expected cost of mass producing it is about one-half that of the BUDOCKS lock. It was recommended that the final design of the NCEL lock be considered satisfactory for BUDOCKS requirements for interior use.

TR-105 Y-F011-05-202
RADIOLOGICAL DECONTAMINATION METHODS AND EQUIPMENT FOR COLD-WEATHER REGIONS, D. Taylor, E. N. Hellberg, W. R. Nehlsen, and L. K. Donovan, 27 Sep 61, 89 pp.

This report is to be used along with NAVDOCKS TP-PL-13, "Radiological Recovery of Field Military Installations," in order to adapt TP-PL-13 to cold-weather conditions. The effects of cold weather upon the operation of the basic recovery plan are pointed out, the major problem areas most likely to be encountered in recovering a fixed military installation subjected to radiological contamination in cold climatic conditions are outlined, and methods and equipment to be used for radiological decontamination are indicated and illustrated for various cold-weather conditions. The judgments were based in large part on appended reports of arctic tests which were designed to augment existing decontamination information.

TR-172 Y-F011-05-203
RADIOLOGICAL DECONTAMINATION SWEEPER, W. R. Nehlsen, 18 Oct 61, 17 pp.

Three types of pavement sweepers were investigated to determine their adaptability for high-rate radiological decontamination. A runway sweeper utilizing an air nozzle pickup was found to be not adaptable. Ordinary street sweepers can perform limited services as decontamination sweepers, but were not suitable for complete development as high-rate units. A sweeper developed for Air Force decontamination needs, the ARDC 100DS, was adaptable to the task requirements.

TN-481 Y-F011-05-202
SIMULATED COLD WEATHER RADIOLOGICAL DECONTAMINATION OF RECOVERY EQUIPMENT, A. E. Hanna, 15 Jan 63, 13 pp.

Tests were conducted in temperatures down to minus 10 degrees F in NCEL's Cold Chamber, in which compressed air, steam, vacuum, water, and antifreeze solution were used to remove a fluorescent fallout simulant from a large tractor. It was concluded that antifreeze solution and water, if warmed, are the most effective materials; steam may be acceptably effective, and air and vacuum have limited use.

TR-219 Y-F011-05-201
SETTLING AND FILTERING EQUIPMENT FOR ROOF-WASHDOWN RADIOLOGICAL COUNTERMEASURES, E. N. Hellberg, 8 Feb 63, 26 pp.

Tests were made to determine if radioactive fallout particles can be removed from roof-washdown water by settling and filtering, thus permitting continuous use of the water by recirculation. A settling tank, a filtering tank, a circulating pump, a flocculent injector, and other allied mechanical equipment were used in the tests. The fallout simulant was sand of various particle sizes tagged with a radioactive tracer. Since a roof section was not used in the tests, the simulant was fed directly into a sloping, open channel which returned the wash water from the filtering tank to the settling tank. It was concluded that settling and filtering tanks connected in series permit satisfactory separation of the simulant from the wash water. It was further concluded that a recirculating-water roof-washdown system using settling and filtering tanks is feasible.

5.3 Barrier Shielding

NBy-13028 (AN-108)
DOSE ATTENUATION BY SOILS AND CONCRETE FOR BROAD PARALLEL-BEAM NEUTRON SOURCES, D. Spielberg and A. Dunner, Associated Nucleonics, Inc., 975 Stewart Ave., Garden City, N. Y., 1 May 58, 162 pp.

This report presents the theory and results of neutron shielding studies performed to supply information for underground bomb shelter design. For neutron source energies of 0.025 ev, 0.5 Mev, 2.5 Mev, 7.5 Mev, 10 Mev, and 14 Mev, and various angles of incidence upon the ground, results are presented that show the total neutron plus secondary gamma dose rates which would be received by individuals located in shelters at various distances below ground. Four basically different soil types were analyzed with water contents from zero to saturation. This range also includes concrete. Dose rates were calculated for depths from 30 to 1,000 grams/cm^2.

NBy-3160 (BoyA c-3160 FR-59-1)
FEASIBILITY STUDY OF EXPERIMENTAL INVESTIGATION OF NEUTRON AND GAMMA RAY PENETRATION, FINAL REPORT, W. W. Boynton, et al., Boynton Associates, Scientists and Engineers, 1018 Olive Lane, La Canada, California, Jan 59, 148 pp.

A feasibility study was made to determine the practicability of doing experimental work on the penetration of neutrons and gamma rays in various soils and materials used in the building of protective shelters. The report presents: (1) a review of available information regarding shielding of both gamma rays and neutrons; (2) a review of methods for neutron and gamma ray measurement; (3) a survey of sources for producing neutrons; (4) methods of approach to an experimental program, including scale of experimentation, facility requirements, radiation sources, detection and measurement techniques; (5) a recommended experimental program; and (6) a cost estimate of such a program.

TR-025 Y-F011-05-329
NUCLEAR RADIATION SHIELDING PROVIDED BY BURIED SHELTERS, J. C. LeDoux, 27 Oct 59, 71 pp.

This report presents methods of calculating the attenuation of initial gamma, initial neutron, and residual gamma radiation incident upon buried shelters from fission-type weapons. Attenuation curves are presented which account for variation in the moisture content and density of the soil cover. The effect of the various energy spectra for each type of radiation has been considered. Three types of shelter configurations have been investigated: the rectangular or slab, the hemisphere, and the arch.

TN-381 Y-F011-05-329
ANALYSIS OF THE CRITICAL SHIELDING VOLUME FOR UNDERGROUND SHELTERS, J. C. LeDoux, Feb 60, 29 pp.

This paper is an interim technical note on the over-all subject of the gamma and neutron shielding properties of shelters and a final report on the results of a study to determine the volume of soil above a buried shelter which is important as a shield against nuclear radiation. This volume of soil is here defined as "the critical shielding volume."

TR-084 Y-R011-01-006
LITERATURE SURVEY OF CONCRETES FOR NUCLEAR RADIATION SHIELDING, M. Merrill and W. L. Cowell, 28 Jun 60, 31 pp.

A literature survey was made of shielding materials used as aggregates in concrete. Information is presented on (1) mix designs incorporating various types of heavy aggregates, (2) available cost data relating to construction methods and aggregates, (3) problems associated with heavy concretes during construction, and (4) nuclear shielding properties for concretes. It was concluded that there were no materials that could compete economically with barite and iron ores. Of the iron ores, magnetite is the most popular. Of the high cross-section materials for thermal neutron absorption, boron is generally the most economical.

TR-080 Y-F011-05-329
SHIELDING FACTORS FOR VARIOUS GEOMETRIC SHAPES, J. C. LeDoux and L. K. Donovan, 5 Apr 61, 49 pp.

This study investigated the additional nuclear shielding from an isotropic (plane) radioactive gamma source afforded by various shapes of underground curved-roof shelters compared to the basic slab shield. This additional shielding is defined in the form of a dimensionless Geometry Factor which is a function of the physical dimensions and shape of the shelter. Curves are presented from which the Geometry Factors for the underground shelter shapes of spheres, horizontal cylinders, ellipsoids, and vertical cylinders or silos can be obtained with minimum calculations using only the physical dimensions of the shelter and the depth of material above the crown of the shelter.

TR-137 Y-F011-05-329
DOSE ATTENUATION FACTORS FOR CONCRETE SLAB SHIELDS COVERED WITH FALLOUT AS A FUNCTION OF TIME AFTER FISSION, L. K. Donovan and A. B. Chilton, 1 Jun 61, 31 pp.

This study was made to investigate the dose attenuation of fallout gamma radiation by various thicknesses of concrete roofs of buried fallout shelters as a function of the time after a nuclear detonation. A spectrum of energies was used for the fallout source rather than a single average energy as has been done in previous studies. Dose attenuation

factors were derived as a function of the above parameters. An average dose attenuation factor is given for various roof thicknesses and for any fourteen-day stay time as a function of time of arrival or shelter-entry time.

5.4 Attenuation in Entranceways and Ducts

NBy-3185 (ARF 1158-12)
RADIATION STREAMING IN SHELTER ENTRANCEWAYS, C. W. Terrell et al., Armour Research Foundation of Illinois Institute of Technology, Chicago 16, Illinois, Oct 60, 95 pp.

This report covers the first year of a continuing task. The basic objective for the first year was to study, describe, and measure the transport of nuclear radiation through air ducts having walls of different materials. Particular emphasis was placed on full scale concrete ducts which are intended for use as underground shelter entranceways and contain a right-angle bend. It was shown that a modified albedo theory will rather accurately describe the transmission of both gammas and neutrons in lead and concrete ducts. Theory was compared with experimental measurements of gamma dose and neutron flux attenuation factors. Neutron number albedo measurements were made. Works by various theorists and experimenters are included for completeness and comparison.

TN-383 Y-F011-05-329
ATTENUATION OF GAMMA RADIATION THROUGH TWO-LEGGED RECTANGULAR DUCTS AND SHELTER ENTRANCEWAYS -- AN ANALYTICAL APPROACH, J. C. LeDoux and A. B. Chilton, 20 Jan 61, 50 pp.

An analytical approach was developed for the determination of gamma radiation attenuation through two-legged rectangular ducts and shelter entranceways. The approach used employs the isotropic albedo concept for wall scattering and includes correction terms necessary to account for the "corner lip effect." Simple engineering formulas were obtained by the use of appropriate simplifying assumptions.

TN-412 (Sequel to TN-383) Y-F011-05-329
FURTHER ANALYSIS OF GAMMA RAY ATTENUATION IN TWO-LEGGED RECTANGULAR DUCTS, A. B. Chilton, 11 May 61, 17 pp.

The use of the isotropic albedo approach for the analytical prediction of gamma ray attenuation in two-legged rectangular ducts was extended to cases involving the asymmetrical location of the source and/or the detector. Illustrative problems are presented and solved.

NBy-3185 (ARF 1158A01-5 (Final Report))
RADIATION STREAMING IN SHELTER ENTRANCEWAYS, C. W. Terrell and A. J. Jerri, Armour Research Foundation of Illinois Institute of Technology, Chicago 16, Illinois, Jul 61, 99 pp.

This report covers the second year of an analytical and experimental investigation of nuclear radiation streaming in ducts and shelter entranceways. The work on the energy dependence of duct attenuation was extended for gamma rays. Further duct geometry dependence was measured. Thermal neutron attenuation was determined for a non-point source and the neutron attenuation was found to be extremely small. Use of albedo theory to successfully describe the radiation streaming of gamma rays was further strengthened and a computer code was prepared to describe the streaming in a straight duct. An analytical analysis of a straight duct, using albedo theory, is included in the appendix along with an outline of future research needs.

NBy-3185 (ARF 1158A02-7 (Final Report))
RADIATION STREAMING IN DUCTS AND SHELTER ENTRANCEWAYS, C. W. Terrell, A. J. Jerri, and R. O. Lyday, Jr., Armour Research Foundation of Illinois Institute of Technology, Chicago 16, Illinois, Apr 62, 50 pp.

This report covers the third year of an analytical and experimental investigation of the streaming of gamma rays and neutrons through ducts and personnel shelter entranceways. The attenuation of gamma rays in concrete-walled ducts having two right-angle bends was measured. Both Z and U shapes were studied experimentally. The addition of a second right-angle bend resulted in a large increase in the attenuation for gamma rays and the energy dependence of the attenuation was considerably reduced. For smaller ducts of one foot square cross section, the attenuation of the second bend was far greater than for the larger cross section entranceway. A recommendation was made to conduct additional work covering the measurement of neutron dose attenuation for the same ducts.

TR-195 Y-F011-05-329(b)
ATTENUATION OF GAMMA RADIATION IN A TWO-LEGGED 11-INCH RECTANGULAR DUCT, D. W. Green, 2 May 62, 52 pp.

Results are presented of experiments with an 11 x 11-inch concrete duct with one right-angle bend. A Co^{60} gamma ray source was used. An empirical expression was obtained which adequately represents most of the experimental results.

TN-443 Y-F011-05-329
GAMMA DOSE RATES AND ENERGY SPECTRA IN A 3-FOOT SQUARE DUCT, J. M. Chapman, 29 Jun 62, 38 pp.

Dosimeter measurements and gamma ray spectra were taken in a 3-foot square concrete duct. The spectra were used to determine the dose rate contributions from the individual scattering areas and to determine the percentage of these dose rate contributions due to multiple scattering in the first leg. Dose rates were compared with calculated values, and it was found that calculated values were always low. This discrepancy was attributed to the effects of multiple scattering.

TN-465 Y-F011-05-329(b)
GAMMA RAY ATTENUATION IN A 12-INCH DIAMETER ROUND CONCRETE DUCT, T. R. Fowler and C. H. Dorn, 5 Nov 62, 30 pp.

Dosimeter and Geiger tube measurements were made along the centerline of a 12-inch diameter circular concrete duct with two right-angle bends. Measurements showed that the build-up factor in the first leg was the same as that found in earlier work for the square duct. As with the square duct, the dosage received down one leg of the duct followed closely the functional form Kx^{-m}, where x is the distance along the axis of the duct, and K and m are empirical constants. The value of m for a round duct had been found to be about 10 percent smaller than that for square ducts of similar size. The attenuation of the corner, however, was greater for a round duct than for a square one. A theoretical treatment of the first leg using single-scattering theory is included in the appendix.

TR-228 Y-F011-05-329(b)
A SEMIEMPIRICAL FORMULA FOR DIFFERENTIAL DOSE ALBEDO FOR GAMMA RAYS ON CONCRETE, A. B. Chilton and C. M. Huddleston, 16 Nov 62, 24 pp.

A semiempirical formula was developed which yields values for the differential dose albedo of gamma rays on concrete. Gamma rays of incident energies 0.2, 0.5, 1.0, 2.0, 4.0, 6.0, and 10.0 Mev were considered. Results of the formula were compared with values derived from Monte Carlo calculations for the backscattering of gamma rays from a semi-infinite slab of concrete. Results showed that a two-parameter formula gives satisfactory agreement with the Monte Carlo calculations. The principal assumption involved in the theoretical analysis was that the actual reflection process can be approximated by two terms, one involving a single Compton scattering event and the other involving isotropic scattering.

TN-469 Y-F011-05-329(b)
SOME APPLICATIONS OF A SEMIEMPIRICAL FORMULA FOR DIFFERENTIAL DOSE ALBEDO FOR GAMMA RAYS ON CONCRETE, W. C. Ingold, 30 Nov 62, 23 pp.

This theoretical study illustrates the usefulness and versatility of a semiempirical formula through its application to three specific problems: (1) in generating a table of albedo values for various combinations of angles of scatter, (2) in a study of first reflection contribution to dose rate in a round duct compared to that in a square duct, and (3) in the development of a relatively simple and unsophisticated program for multiple scatter contributions.

TN-478 Y-F011-05-329(b)
A MATHEMATICAL APPROACH TO ECONOMY OF EXPERIMENT IN DETERMINATIONS OF THE DIFFERENTIAL DOSE ALBEDO OF GAMMA RAYS, N. F. Shoemaker and C. M. Huddleston, 10 Dec 62, 19 pp.

Treatments of the differential dose albedo of gamma rays on concrete have assumed that the albedo value is a function of: the energy of the incident gamma radiation, the polar angle of incidence, the polar angle of reflection (or scatter), and the azimuthal angle of reflection. It is demonstrated in this report that, if certain reasonable assumptions are made regarding the mechanism of reflection, it is not necessary to investigate variations in albedo with azimuth angle of reflection. Once differential dose albedo has been determined for a complete set of incident and reflection polar angles with zero azimuth, albedo at any azimuth can be derived by a suitable transformation.

6. MECHANICAL ENGINEERING SYSTEMS

6.1 Power

Several engine-driven generator sets, both diesel and gasoline fueled, have been tested at the Laboratory. Although these sets were tested for advanced base use, they might be adaptable for shelter use; therefore, they are listed herein.

TN-308 NY 211 001-1.03
EVALUATION OF 60 KW ALUMINUM DIESEL-ELECTRIC GENERATOR SETS -- GMC, R. H. Leseberg and L. Cromwell, 31 Jul 57, 19 pp., FOR OFFICIAL USE ONLY.

TN-314 NY 211 001-1.11
EVALUATION OF 150 KW DIESEL ENGINE GENERATOR SETS -- GMC, R. H. Leseberg, J. H. Sams, and L. Cromwell, Jul 57, 39 pp., FOR OFFICIAL USE ONLY.

TN-310 NY 211 001-1.10
EVALUATION OF 150 KW DIESEL-ELECTRIC GENERATOR SETS -- CUMMINS, R. H. Leseberg, J. H. Sams, and L. Cromwell, 22 Aug 57, 43 pp., FOR OFFICIAL USE ONLY.

TN-311 NY 211 001-1.06
EVALUATION OF 60 KW DIESEL-ELECTRIC GENERATOR SETS -- CATERPILLAR, R. H. Leseberg, J. H. Sams, and L. Cromwell, 23 Aug 57, 51 pp., FOR OFFICIAL USE ONLY.

TN-313 NY 211 001-1.02
EVALUATION OF 30 KW DIESEL ENGINE GENERATOR SETS -- BUDA, R. H. Leseberg and L. Cromwell, 5 Sep 57, 31 pp., FOR OFFICIAL USE ONLY.

TN-315 NY 211 001-1.07
EVALUATION OF 100 KW ALUMINUM DIESEL ENGINE GENERATOR SETS -- GMC, R. H. Leseberg, J. H. Sams, and L. Cromwell, Sep 57, 37 pp., FOR OFFICIAL USE ONLY.

TN-316 NY 211 001-1.05
EVALUATION OF 60 KW DIESEL ENGINE GENERATOR SETS -- HARNISCHFEGER, R. H. Leseberg and L. Cromwell, Sep 57, 13 pp., FOR OFFICIAL USE ONLY.

TN-317 NY 211 001-1.13
EVALUATION OF DIESEL GENERATOR SETS -- 10 KW WHITE, J. Weinroth, R. H. Leseberg, and L. Cromwell, Sep 57, 41 pp., FOR OFFICIAL USE ONLY.

TN-318 NY 211 001-1.13
EVALUATION OF SMALL DIESEL GENERATORS -- FAIRBANKS MORSE, R. H. Leseberg, J. Weinroth, and L. Cromwell, 9 Sep 57, 23 pp., FOR OFFICIAL USE ONLY.

TR-032 NY 411 002-2.01
DEVELOPMENT OF A BRUSHLESS REGULATED AC GENERATOR OF RADIO-INTERFERENCE-FREE DESIGN, A. M. Brown, 7 Sep 59, 42 pp.

Preliminary testing of the prototype generator developed under the project showed that burshless construction is feasible, will perform to Naval specifications of voltage regulation, and will eliminate radio interference resulting from brushes, slip rings, and commutators.

TN-378 Y-F015-11-601 NY 211 001-1.08
EVALUATION OF A 100 KW DIESEL-ELECTRIC GENERATOR SET -- CATERPILLAR, R. H. Leseberg and J. H. Sams, 30 Dec 59, 25 pp., FOR OFFICIAL USE ONLY.

TR-063 Y-F015-11-601
EVALUATION OF 60 KW WINTERIZED DIESEL ENGINE GENERATOR SETS -- CATERPILLAR, R. H. Leseberg and J. H. Sams, 20 Apr 60, 49 pp., FOR OFFICIAL USE ONLY.

TN-387 Y-F015-11-601
EVALUATION OF 60 KW GASOLINE ENGINE-DRIVEN GENERATOR SETS -- STONE, R. H. Leseberg and J. H. Sams, 15 Aug 60, 19 pp., FOR OFFICIAL USE ONLY.

TN-369 Y-F015-11-601
EVALUATION OF SMALL DIESEL ENGINE-DRIVEN GENERATOR SETS -- 15 KW HOBART, R. H. Leseberg and J. H. Sams, 29 Aug 60, 31 pp., FOR OFFICIAL USE ONLY.

TN-411 Y-F015-11-601
EVALUATION OF A 150 KW TURBO-CHARGED DIESEL ENGINE-DRIVEN GENERATOR SET -- CATERPILLAR, R. H. Leseberg and J. H. Sams, 21 Jun 61, 32 pp., FOR OFFICIAL USE ONLY.

TR-203 Y-F015-11-601
EVALUATION OF SMALL DIESEL-ENGINE-DRIVEN GENERATOR SETS -- 5 KW HOBART, R. H. Leseberg, 29 Jun 62, 29 pp., FOR OFFICIAL USE ONLY.

TR-222 Y-F006-09-301
1000-HOUR TEST OF 30-KW BRUSHLESS GENERATOR SET, R. H. Leseberg, 23 Nov 62, 35 pp.

The Laboratory evaluated a 30-kw diesel-engine-driven generator set that had been modified under a contract with the Leach Corporation, Inet-Palmer Special Products Division of Los Angeles, California. The set was modified to incorporate a brushless generator design and a static-type voltage regulator. The 30-kw modified brushless generator set was found to have excellent power-generating characteristics for 60-cps operation at the 120/208 voltage connection. It completed more than 1000 hours of operation at various power factor loads, and the average voltage-droop characteristics indicated that two similar units could be expected to operate satisfactorily in parallel.

6.2 Air Supply and Air Treatment

TM-035 NY 300 01B-1
BUILDING PROTECTION AGAINST BIOLOGICAL WARFARE ATTACK, W. Viessman and E. N. Hellberg, 1 Feb 52, 19 pp.

The abstract is presented on page 5.

TN-110 YD 500-2
VENTILATION STUDY OF A 20 FT BY 48 FT QUONSET-TYPE BUILDING, K. B. Edwards and W. Viessman, 18 Aug 52, 29 pp.

This building, designed for 16 men in temperate climates, was found to require 3.16 air changes per hour, or 400 cfm, when the differential temperature of inside and outside air is 10 F and the wind velocity is 5 mph. For short periods of no wind, the ventilation system should be designed to provide a minimum of 128 cfm.

NOy-22273
PRESSURIZATION OF BUILDINGS, Final Report, C. E. Lund and R. E. Paul, University of Minnesota Engineering Experiment Station, 17 Nov 52, 76 pp.

Materials are recommended and design details are given for sealing buildings at pressures not exceeding one inch of water. Studies were made on a small test house.

TN-221 NY 300 006-3
INVESTIGATION OF UNPRESSURIZED SHELTER REQUIREMENTS AND EQUIPMENT, J. J. Traffalis and W. R. Nehlsen, 18 May 55, 14 pp.

It was concluded that a manually operated collective protector is the most economical method of solving the problems of oxygen, CO_2, temperature, humidity, and entrance and exit of personnel. The necessity of sealing is not removed, but the quality of sealing required may be reduced.

TN-231 NY 412 030-3
EVALUATION OF U. S. AIRCO MODEL NA 94520 DEHUMIDIFIER, K. B. Edwards, J. H. Sams, and W. B. Mitchell, 16 Sep 55, 17 pp., FOR OFFICIAL USE ONLY.

The U. S. Airco Model NA 94520 Dehumidifier was tested to determine its capacity and power consumption and to determine its suitability for dehumidification of warehouses.

TN-277 NY 300 010-1
VENTILATION SYSTEM PROTECTION AGAINST BW AEROSOLS, W. R. Nehlsen, 27 Jun 56, 7 pp.

The abstract is presented on page 5.

TN-287 NY 300 010-1
ARRESTANCE, RESISTANCE, AND DUST-LOADING TESTS ON COMMERCIAL AIR FILTERS, E. N. Hellberg and W. R. Nehlsen, 1 Feb 57, 53 pp.

The abstract is presented on page 6.

TN-296 NY 300 006-3
SELF-CONTAINED SHELTER KIT FOR ATMOSPHERIC CONTROL OF SEALED SHELTERS, W. R. Nehlsen, 1 Mar 57, 19 pp.

A hand-operated collective protector and a single chamber air lock were developed and tested with good results. Oxygen generating chemicals are less expensive, but are also less useful.

TM-127 NY 300 010-1
AEROSOL TRAVEL THROUGH VENTILATION SYSTEMS, E. N. Hellberg, 11 Jun 57, 83 pp.

The abstract is presented on page 6.

TN-354 Y-F011-05-401(b)
SHELTER HABITABILITY STUDIES: THE EFFECT OF ODOR IN A SHELTER AND VENTILATION REQUIREMENTS, J. S. Muraoka, 22 Nov 60, 18 pp.

The abstract is presented on page 3.

TR-146 Y-F011-05-401(b)
SHELTER HABITABILITY STUDIES: ODORS AND REQUIREMENTS FOR VENTILATION, J. S. Muraoka, 8 May 61, 19 pp.

The abstract is presented on page 3.

TR-151 APWO 59-00-15
LITHIUM HYDROXIDE CANISTERS FOR PERSONNEL SHELTERS, R. J. Zablodil, J. M. Stephenson, and R. S. Chapler, 13 Jun 61, 25 pp.

A canister-blower device with two lithium hydroxide canisters in parallel was developed to reduce the CO_2 in personnel shelters. Operational instructions are provided with a chart showing when and how to use the equipment.

TR-144 Y-F011-05-401(b)
SHELTER HABITABILITY STUDIES: THE EFFECT OF OXYGEN DEPLETION AND FIRE GASES ON OCCUPANTS OF SHELTERS, J. S. Muraoka, 18 Jul 61, 33 pp.

The abstract is presented on page 4.

TR-156 Y-F011-08-327
STATISTICAL ANALYSIS OF SIX VENTILATION AIR FILTERS, E. N. Hellberg, 24 Jul 61, 19 pp., FOR OFFICIAL USE ONLY.

A statistical analysis was made of six different commercial air filters to determine the most promising for protective or decontamination applicability for BW-CW defense.

TN-471 Y-F011-05-340
GRAVITY VENTILATION OF PROTECTIVE SHELTERS, E. J. Beck, Jr., 8 Jul 63, 12 pp.

The possibilities, limitations, and some alternates for simple augmentation of natural draft are outlined. These include the use of a flame in a flue, both with and without thermoelectric power generation. A simple design procedure and demonstration test program are outlined.

6.3 Waste Disposal

TN-225 NY 412 021
DEVELOPMENT OF A BIOLOGICAL OXIDATION PACKAGE WASTE DISPOSAL UNIT, W. R. Nehlsen, 12 Jul 55, 10 pp.

The Arctic barracks package sewage disposal unit designed by NCEL was field tested for four months by the personnel of the Army Yuma Test Station. The test revealed that the prototype with its 100 gallon aeration tank will handle the sewage for approximately five men.

TN-295 NY 412 021
TEST OF A BIOLOGICAL OXIDATION PACKAGE WASTE DISPOSAL UNIT, W. R. Nehlsen, 10 Apr 57, 9 pp., FOR OFFICIAL USE ONLY.

TN-356 NY 000 013-10.02
EVALUATION OF ELECTRIC INCINERATING TOILET, W. R. Nehlsen, 6 Mar 59, 9 pp., FOR OFFICIAL USE ONLY.

TN-377 Y-F015-11-211 NY 000 013-10.01
WASTE DISPOSAL SYSTEMS FOR POLAR CAMPS, W. R. Nehlsen, 18 Nov 59, 21 pp., FOR OFFICIAL USE ONLY.

TR-104 Y-F015-11-213
EVALUATION OF SANITOI TYPE B WASTE-DISPOSAL SYSTEM IN POLAR CAMP USE, W. R. Nehlsen, 25 Oct 60, 13 pp., FOR OFFICIAL USE ONLY.

TN-406 Y-F015-11-212
INCINERATING TOILETS, W. R. Nehlsen, 20 Mar 61, 7 pp., FOR OFFICIAL USE ONLY.

NBy-32205
SANITARY WASTE DISPOSAL FOR NAVY CAMPS IN POLAR REGIONS, Clark & Croff Engineers, Salem, Oregon, May 62, 243 pp.

This report covers: (1) waste collection and disposal practices currently in use, (2) establishment of military characteristics and sanitary criteria, (3) an enumeration and evaluation of all concepts of handling and disposal, and (4) recommendations for research leading to improved facilities.

TN-476 Y-F015-11-211
A DEVELOPMENT PROGRAM FOR POLAR CAMP SANITATION, W. R. Nehlsen, 28 Dec 62, 21 pp.

It is concluded that research and development work should continue in: (1) improved applicatication of water carriage sewage systems, including development of minimum water use appurtenances and criteria, and studies of heating and insulating sewers; and (2) development of surface and sub-surface sea intake systems.

7. CIVIL ENGINEERING SYSTEMS

7.1 General

TM-121 NY 420 009
TESTS OF CONCRETE DEADMAN ANCHORAGES IN SAND,
J. E. Smith, Feb 57.

See the abstract for TR-199 on page 30.

NBy-3150
FEASIBILITY STUDY CONCERNING THE UTILIZATION OF PLASTICS FOR UNDERGROUND PERSONNEL SHELTERS, Massachusetts Institute of Technology, Cambridge 39, Mass., Sep 59, 98 pp.

An investigation was made of the feasibility and practicability of using plastic materials for the structural components of underground personnel shelters. It was found that fiberglass reinforced plastic is the only suitable, available plastic material. Nuclear effects, layout and surface geometry, and dynamic structural behavior were considered.

TR-074 Y-F008-10-102 NY 340 030-11
PARAFFIN AS A CONDUIT SEAL AGAINST BLAST PRESSURE,
H. G. Aggas, 18 Feb 60, 13 pp.

Tests were conducted to determine the blast resistance of paraffin as a sealing compound in Crouse-Hinds explosion-proof sealoffs. These sealoffs, which had approximately one-half of their cross-sectional area filled with standard electrical wire, were sealed with paraffin and tested in the blast simulator. Paraffin was an effective seal for resisting dynamic and static pressures to at least 150 psi at an average temperature of 68° F. The sealoffs were subjected to dynamic pressures up to 170 psi with no damage to the wax seal.

TR-073 Y-F015-15-001
PASSIVE RESISTANCE OF EARTH-ANCHORS IN SAND, PART II,
J. E. Smith, 8 Mar 60, 54 pp.

See the abstract for TR-199 on page 30.

TR-123 Y-F011-05-328
METHODS OF SHOTCRETE CONSTRUCTION FOR PERSONNEL SHELTERS,
R. M. Webb, 17 Mar 61, 39 pp.

To evaluate methods for the economical construction of shotcrete personnel shelters, shotcrete arches were cast over various forms: a Quonset arch, a flexible plywood shell, a pneumatic airform, and a compacted earth mound. Salvageable Quonsets were found to be the most economical. Wet-mix shot-

crete containing coarse aggregate was placed which permitted use of conventional concrete mixes.

TR-199 Y-F015-15-001
DEADMAN ANCHORAGES IN SAND, (Final Report), J. E. Smith, 12 Jul 62, 77 pp.

A test program was conducted to obtain information for improving or expanding design criteria for deadman anchorages in sand as used for the lateral support of engineering structures. Horizontal loads were applied to reinforced concrete deadmen, ranging in size from 5 to 72 square feet of face area, placed singly and in rectilinear groups of three at several depths. The 72-square-foot deadman also was tested behind triangular and trapezoidal berms of different sizes. Satisfactory correlation of results was obtained from the tests. Deadman holding capacities and reaction patterns under applied loads were determined and an empirical equation by which both the capacities and reaction patterns can be calculated was developed. In addition, failure-wedge development and extent were defined and information was obtained concerning the effect of coupling elevation and repeated loads on holding capacity.

TN-454 Y-F015-11-604
RAPID TUNNELING EQUIPMENT AND TECHNIQUES, D. Taylor, 20 Sep 62, 27 pp., FOR OFFICIAL USE ONLY.

A study of existing reports and information for commercial tunneling equipment and methods was conducted to provide information about rapid tunneling, and to determine which equipment can be adopted by naval construction forces at advanced bases to permit underground operations. An outline is given for a manual on rapid tunneling equipment and techniques.

TR-231
EFFECTS ON STRUCTURAL AND HARBOR INSTALLATIONS OF GROUND SHOCK INDUCED BY UNDERWATER EXPLOSIONS, L. W. Heller, 30 Jun 63, SECRET.

7.2 Rapid Closing Valves

TN-360 NY 340 033-4
CORROSION STUDIES ASSOCIATED WITH AN AIR BLAST CLOSURE UNIT, C. V. Brouillette, 30 Jul 59, 52 pp.

Eleven months exposure of an air blast closure unit, fabricated from a combination of several different metals and alloys, resulted in the formation of a sufficient quantity of corrosion products to render the closure unit of doubtful operational value.

TN-439 Y-F008-10-111
PERFORMANCE OF THE SWEDISH RAPID-CLOSING ANTI-BLAST VALVE,
E. N. Hellberg, 9 May 62, 17 pp.

A 14-inch diameter Swedish anti-blast valve was tested for air flow and weatherability. Blast resistance tests were not made since similar valves were tested previously in Sweden at 280 psi with no damage. Air flows from 1830 to 3680 cfm produced pressure losses from 1.28 to 4.56 inches of water when air was drawn through the valve. Air flows from 1830 to 4750 cfm produced pressure losses from 0.25 to 2.56 inches of water when air was exhausted from the valve. Without the shear pin holding the closure disc fixed, fluttering became serious at air flows in excess of 900 cfm. The free movement of the closure disc was unaffected by ten months of outside storage and the valve in general was virtually rust-free.

TN-460 Y-F008-10-117
PRELIMINARY DEVELOPMENT AND TESTS OF A BLAST-CLOSURE VALVE,
R. A. Breckenridge, Sep 62, 23 pp.

This technical note discussed a 600-cfm blast-actuated closure valve being developed at the Laboratory for overpressure up to 100 psi. A series of air-flow and blast tests were performed which show that the valve has the potential to satisfy all the desirable criteria but requires further develpoment. The valve probably would be installed in the duct system external to the shelter (i.e., buried in the ground) but could be placed within the shelter. Although the valve under development is for use with 8-inch standard steel pipe, similar valves could be developed for other size pipes.

TN-491 Y-F008-10-117b
PRELIMINARY TESTS OF THE STEPHENSON VALVE, J. M. Stephenson and
R. S. Chapler, 8 Mar 63, 8 pp.

The Stephenson valve consists of a steel tube containing polyurethane open cell foam balls. The balls are actually cylindrical in shape, approximately 1-3/4 inch diameter and 1 inch long. A special shock tube was used to test the ability of the valve to attenuate blasts. The valve is 8 inches in diameter and was connected to a 45-cubic foot tank representing the shelter. Shock waves with overpressures up to 90 psi and with positive durations of 2 seconds were applied to the valve. The maximum pressure recorded in the "shelter" was 2 psi. Air flow tests were also made on the 8-inch valve and it was calculated that a 48-inch diameter valve could transmit 1200 cfm of air with a pressure drop of 0.175 inches of water. This valve is also capable of filtering dust from the air but no tests were made to determine dust arrestance characteristics.

TN-514 Y-F011-05-338(a) DASA 13.154
RESPONSE CHARACTERISTICS OF THE 48-INCH DIAMETER MOSLER BLAST CLOSURE VALVE, E. N. Hellberg, 15 Jul 63, 14 pp., FOR OFFICIAL USE ONLY.

The 48-inch diameter Mosler blast closure valve was tested to determine its air flow characteristics, closure time, and response to blast pressures.

TN-529 Y-F011-05-338(a) DASA 13.154
PERFORMANCE OF THE AMF 36- AND 48-INCH BLAST CLOSURE DEVICES, E. N. Hellberg, 12 Aug 63, 18 pp., FOR OFFICIAL USE ONLY.

The 36- and 48-inch AMF blast closure devices were tested to determine their air flow characteristics, closure times, blast resistance, and weatherability.

7.3 Dynamic Loading and Response

TN-159 NY 340 010-4
STATIC AND DYNAMIC STUDIES OF THREE PERSONNEL SHELTERS: ARMCO II, STRUCTURE 3.15, STRUCTURE 3.13a, J. R. Allgood, C. K. Weihle, and W. A. Shaw, Jun 53, SECRET.

NOy-73231
DYNAMIC RESPONSE OF BEAMS IN AND BEYOND THE ELASTIC RANGE, W. T. Thomason, J. M. English, and J. A. Cheney, Department of Engineering, University of California at Los Angeles, Aug 53, 62 pp.

This report presents an electronic analog procedure of obtaining the response of beams to an arbitrary impulsive loading in and beyond the elastic range. Several solutions for the elastic range and one solution in the plastic range are given.

TN-170 NY 340 030
THE RESISTANCE OF PANELS TO STATIC AND DYNAMIC LOADS, J. R. Allgood, Nov 53, SECRET.

NOy-73231
PLASTIC BEHAVIOR OF BEAMS UNDER LONG DURATION IMPULSIVE LOADS, W. T. Thomson, Department of Engineering, University of California at Los Angeles, Oct 54, 30 pp.

Dynamics of the simply supported beam under plastic deformation is simulated by an electric analog computer including damping and elastic return.

TN-200 NY 340 030
DYNAMIC ELASTO-PLASTIC TESTS ON SMALL SCALE BEAMS, J. R. Allgood and W. A. Shaw, 27 Oct 54, 75 pp.

This note covers the first phase of an experimental test program to determine the response of small reinforced concrete beams subjected to step concentrated impulse loads. A description is given of the test beams, the instrumentation, and the test procedure. The response data is presented in tables, graphs, and oscillograms. Experimental results agree with theory when effects of damping are considered.

NOy-28149
A PHOTOELASTIC STUDY OF DYNAMIC STRESSES IN STRUCTURES, FINAL REPORT, M. M. Frocht, Department of Mechanics, Illinois Institute of Technology, Chicago, Illinois, 30 Nov 54, 52 pp.

The report deals primarily with the further development of equipment and techniques for obtaining dynamic stress patterns showing fundamental aspects of stress wave propagation, and with a study of the dynamic stress-optic law which is essential to the proper interpretation of such patterns. It also deals with studies of stress wave propagation in a compression bar, the use of the Fastex camera, experiments with concentrated loads, stress concentrations, and beams under central impact. A detailed account is given of the improvements in the equipment and techniques for streak photography; the propagation of elastic stress waves in a compression bar fixed at one end and struck by a heavy rigid mass at the other end is discussed; the dynamic stress-optic law is discussed and the results from an initial investigation using Castolite and Bakelite is given; preliminary results concerning St. Venant's principle is presented.

NOy-73251
A STUDY AND EVALUATION FOR THE DESIGN OF AN EXPERIMENTAL BLAST SIMULATOR, FINAL REPORT, W. W. Boynton and Associates, Consulting Physicists and Engineers, 1018 Olive Lane, La Canada, Calif., Jan 55.

NOy-73262
PRELIMINARY DESIGN FOR AN AIR BLAST SIMULATOR, FINAL REPORT, Boynton Associates, Scientists and Engineers, 1018 Olive Lane, La Canada, Calif., 8 Aug 55.

The design criteria for the Air Blast Simulator are reviewed and the basic considerations involved in the proposed design are outlined. Preliminary stress calculations and a cost estimate for budget purposes are included. Six drawings are attached.

WT-1130 Operation TEAPOT
TEST OF CONCRETE PANELS, J. R. Allgood and W. A. Shaw, U. S. Naval Civil Engineering Laboratory for Headquarters Field Command, Defense Atomic Support Agency, Sandia Base, Albuquerque, New Mexico, 3 May 57, CONFIDENTIAL.

NOy-73231
DYNAMIC RESPONSE OF SINGLE SPAN BEAMS IN THE PLASTIC REGION, W. T. Thomson, Department of Engineering, University of California at Los Angeles, Jun 57, 30 pp.

This theoretical work considered prismatic beams with fixed ends subjected to uniform dynamic load. Formulas were derived and design curves are given.

TN-322 NY 340 030-11
STATIC RESISTANCE OF REINFORCED CONCRETE BEAMS THROUGH THE ELASTIC AND PLASTIC RANGES, G. R. Swihart, J. R. Allgood, and W. A. Shaw, Oct 57.

A theory is presented for determining the static resistance characteristics of uniformly loaded reinforced concrete beams. Particular attention was given to predicting ultimate deflection. Four loading conditions were considered. The theory was compared with static test data.

TM-130 NY 340 030-11
ELASTO-PLASTIC RESPONSE OF BEAMS TO DYNAMIC LOADS, J. R. Allgood and W. A. Shaw, 3 Mar 58, 103 pp.

A method is given and substantiated for determining the elasto-plastic response of beams subjected to pulse loads. Design charts are presented. The theory was compared with the results of about sixty beam tests.

NBy-3127
HISTORY OF THE DEVELOPMENT, DESIGN, FABRICATION AND PROOF TESTING OF THE ATOMIC BLAST SIMULATOR, Boynton Associates, Scientists and Engineers, 1018 Olive Lane, La Canada, California, Jul 58.

NBy-3127
ATOMIC BLAST SIMULATOR, FINAL REPORT, Boynton Associates, Scientists and Engineers, 1018 Olive Lane, La Canada, Calif., 15 Sep 58, 36 pp.

This report covers work done on the Atomic Blast Simulator in the following phases: (1) engineering supervision, including consultation with bidders, awarding of contracts, concrete construction, steel fabrication, machining, hydrostatic testing and erection; (2) simulator operation; (3) proof testing; and (4) the source of energy and its effects, and a summary of the analysis of the proof testing.

NBy-3127
OPERATION MANUAL OF ATOMIC BLAST SIMULATOR, Boynton Associates, Scientists and Engineers, 1018 Olive Lane, La Canada, Calif., 15 Sep 58, 52 pp.

NBy-3127
DESIGN FOR SUPPLEMENTAL EQUIPMENT FOR ATOMIC BLAST SIMULATOR, FINAL REPORT, Boynton Associates, Scientists & Engineers, 1018 Olive Lane, La Canada, Calif., 25 Sep 58, 22 pp.

NBy-3145
OUTLINE OF TEST PROGRAM FOR THE DYNAMIC TESTING OF VARIOUS STRUCTURAL CONNECTIONS IN THE ATOMIC BLAST SIMULATOR, B. G. Johnston, University of Michigan, Ann Arbor, Michigan, Oct 58, 50 pp.

A plan is outlined for a test program for the dynamic testing of typical structural steel connections using the Atomic Blast Simulator. These connections include portal frame, beam-column, and column anchorage connections, Auxiliary loading devices are described and complete design details of both connections and auxiliary apparatus are presented. Recommended instrumentation, test procedure, and suggestions regarding the interpretation of test results are included.

TR-013 NY 340 030-11
INFLUENCE OF GRADE OF STEEL ON BLAST RESISTANCE OF REINFORCED CONCRETE BEAMS, W. A. Shaw and J. R. Allgood, 1 Jan 59, 23 pp.

A method is presented for comparing different grades of steel as reinforcement in concrete beams subjected to blast loads. It is shown that whether one type of steel is better than another depends primarily upon the criterion of failure selected and the characteristics of the loading. Based upon preselected criteria of failure, the peak dynamic load carrying capacity was calculated for beams of a given configuration but having different percentages and grades of reinforcing steel. These calculations were made for blast-type loads of different duration. From plots of the results, it is shown that the suitability of various grades of reinforcing steel will depend upon the maximum permissible deflection, the characteristics of the loading, and the amount of tension steel used.

NBy-3146
STUDY TO DETERMINE THE OPTIMUM SECTION OF REINFORCED CONCRETE BEAMS SUBJECTED TO BLAST LOADS, G. R. Swihart, University of Nebraska, Lincoln, Nebraska, Feb 59, 49 pp.

This study was performed to determine the combination of parameters which will provide the optimum resistance for reinforced concrete beams subjected to blast loading. The ultimate goal of the study was to enable selection of beams from design charts. Calculations were performed on an electronic digital computer making it possible to include a wide range of variables. The results are presented in twelve design charts. A numerical example illustrating the use of the charts is included.

TR-035 Y-F008-10-102
ELASTO-PLASTIC RESPONSE OF REINFORCED CONCRETE BEAMS TO SHORT-DURATION LOADS, S. K. Takahashi, 25 Sep 59, 21 pp.

Results are presented of experiments and studies performed to define the elasto-plastic response of beams under loads for which the load duration is less than six times the natural period of the member. It is shown that the response of beams to short-duration loads as predicted by the spring-mass theory agrees well with measurements.

TR-078 NS 724-021
DYNAMIC TESTS OF ALUMINUM BEAMS, J. R. Allgood and S. K. Takahashi, 22 Mar 60, 27 pp.

Three built-up 5456-H311 aluminum alloy beams, with a clear span length of 8 ft. 1-3/8 in. and restrained ends, were subjected to uniformly distributed static and dynamic loading. One of the members, tested statically to a 21.6 psi sustained load, buckled at the web. The other two members, subjected to blast loads with peak overpressures of 18.2 psi and 18.5 psi, also buckled at the web. Results are given, the dynamic response of the members is discussed, and a design criterion based on a limit deflection of L/50 is proposed.

NBy-3186
PROGRAM ON THE DYNAMIC TESTING OF STRUCTURAL FRAMES AND ARCHES, B. G. Johnston, University of Michigan, Ann Arbor, Michigan, May 60, 63 pp.

A test program involving welded portal frames, with either hinged or fixed column bases, together with two hinged arches, is described. The proposed tests are scaled to adapt them to the atomic blast simulator. Recommendations are made as to test assembly, instrumentation, and procedure. Auxiliary equipment is described. Alternate test set-ups with or without dynamometers are designed and relative advantages and disadvantages discussed. Design calculations for the test frames and arches and design calculations for auxiliary equipment are given.

TR-121 Y-F008-10-102
DESIGN CHARTS FOR R/C BEAMS SUBJECTED TO BLAST LOADS, J. R. Allgood and G. R. Swihart, 19 Oct 60, 37 pp.

An ultimate load theory was combined with an idealized dynamic theory to form a computational program for the development of a set of design charts for reinforced concrete beams. The behavior of beams under blast loading was reviewed to aid in the explanation of the computational program and the charts. A procedure for the treatment of shear and bond is presented; the design curves are given and exemplified; and their limitations are discussed.

TR-086 Y-F008-10-102
BLAST LOADING OF 15 FT R/C BEAMS, J. R. Allgood, S. K. Takahashi, and W. A. Shaw, 9 Jan 61, 76 pp.

This report presents the results of a series of tests designed to reveal the nature of the dynamic response of restrained R/C beams as compared with simple beams. A secondary aim was to verify the results of previous small-scale beam tests. The test data gave an insight into the complex elasto-plastic action of simple and restrained flexural members. It was found that considerable advantage is to be gained by using restrained members instead of simply-supported ones and that the simulator is an exceptionally reliable and simple loading device.

NBy-32189
ELASTO-PLASTIC RESPONSE OF TWO RIGID FRAMES TO A DISTRIBUTED DYNAMIC LOAD, N. L. Basdekas and R. C. DeHart, Southwest Research Institute, San Antonio, Texas, Mar 61, 119 pp.

This report presents a theoretical solution to the elasto-plastic response of rigid frames with pinned and fixed column bases to a distributed dynamic load. Curves are plotted for deflection and moment vs. time, deflection vs. time, deflection at the time the plastic hinge forms vs. ultimate deflection, and peak dynamic load vs. maximum deflection.

TR-116 Y-F008-10-102C
BLAST LOAD TESTS ON POST-TENSIONED CONCRETE BEAMS, H. T. Miyamoto and J. R. Allgood, 29 May 61, 87 pp.

Four types of post-tensioned prestressed concrete beams with straight unbonded bars were tested under static and blast loading to study their behavior. The tests showed that the response of prestressed beams can be predicted by a one-degree-of-freedom system provided the correct damping and resistance functions are known.

TR-148 S-F013-04-05
BLAST LOADING OF 8-FOOT ALUMINUM BEAMS, S. K. Takahashi and D. F. Green, 9 Jun 61, 43 pp.

Tests were made to determine the dynamic response of aluminum beams, including the determination of the static and dynamic yielding, local buckling, and ultimate buckling loads. Sixteen built-up aluminum alloy beams were tested under uniformly distributed static and blast loads. Based on a yield load with a factor of safety of 1.65, design static and dynamic working loads of 64 and 29 psi respectively are recommended for the specific beams tested. A chart is included which may be used to predict the maximum dynamic deflection of the beams once the static properties are known.

NBy-32203
DAMPING CHARACTERISTICS OF PRESTRESSED CONCRETE, J. Penzien, Institute of Engineering Research, University of California, Berkeley, Calif., Jan 62, 58 pp.

Twenty prestressed concrete beams and four standard reinforced concrete beams were tested under dynamic conditions to determine their general damping characteristics.

TN-427 Y-F008-10-401
DYNAMIC TESTS ON HIGH STRENGTH STEEL, W. L. Cowell and J. R. Keeton, 10 Feb 62, 17 pp., FOR OFFICIAL USE ONLY.

Results are presented of tension tests on specimens machined from special high strength reinforcing steel. Yield stresses were determined using strain rates from the static value of 7×10^{-6} in./in./sec to a dynamic rate of 0.375 in./in./sec. The percent increase in yield stress, for a given dynamic strain rate, was computed. The test results indicated that the percent increase in dynamic yield stress for the high strength steel is lower than that previously reported for conventional reinforcing steels. Compared with static results, the dynamic loading caused a small increase in ultimate strength; there was no significant change in area reduction or percent elongation at rupture.

NBy-32199
THE INFLUENCE OF MECHANICAL SHIELDING ON THE RESPONSE OF A BURIED CYLINDER, D. A. DaDeppo and J. F. Werner, The University of Arizona Engineering Research Laboratory, Tucson, Arizona, Feb 62, 154 pp.

A theoretical investigation of a method of hardening a buried shelter is presented. The method is that of shock isolation or mechanical shielding which may be accomplished by interposing a cushioning material such as foam plastic or light-weight foamed concrete between the soil and the shelter.

TR-183 Y-F008-10-103
STATIC AND DYNAMIC BEHAVIOR OF PORTAL-FRAME KNEE CONNECTIONS, W. A. Shaw, 21 May 62, 251 pp.

Three types of connections (square, curved, and tapered haunch knees) were tested with uniformly distributed static and dynamic loads. The pressure-time function for the dynamic tests was essentially triangular. Peak pressure was achieved in 1 to 2 milliseconds; the pressure decayed to zero in 0.5 to 1.5 seconds. The detailed results were evaluated, and comparisons were made of various connections with regard to energy-absorbing capacity, stiffness, ductility, rotational capacity, and development of the fully plastic yield moment in the wide-flange beam. The single-degree-of-freedom system adequately described the dynamic response of the connections for both elastic and inelastic behavior. The overall performance of the square knee connection was superior to that of the curved or haunched knee connection for both static and dynamic loads.

TR-192 Y-F008-10-102A
STATIC AND DYNAMIC LOADING OF PRETENSIONED CONCRETE BEAMS,
S. K. Takahashi, 15 Jun 62, 87 pp.

Nine simply supported pretensioned beams were tested in the blast simulator either statically or dynamically. A method of predicting the static ultimate deflection is presented and applied to one of the beams. The experimental data are compared with the theory. All of the statically tested beams failed in bond near the supports. In the dynamic tests, two beams failed by concrete compression at mid-span, and the rest failed in bond. A solution for dynamic response, which includes damping, is shown and applied to one of the tests.

NBy-32209 DASA 13.104
THE DYNAMIC BEHAVIOR OF REINFORCED CONCRETE COLUMNS, PART III,
C. Y. Yang and K. F. Reinschmidt, School of Engineering, Massachusetts Institute of Technology, Cambridge 39, Mass., Oct 62, 113 pp.

Two reports of the same title, Parts I and II, were published in September, 1960 and March, 1962 respectively, concerning primarily the ultimate strength and buckling of concentrically loaded columns. Experiments were performed on 185 columns of 5 by 5 inch square section, of different lengths and of different eccentricities of the load. This report covers primarily the theoretical investigation of eccentrically loaded columns. An experimental program of 20 columns was executed. The report includes a summary of results of the first two reports. Comparisons between experimental results and theoretical predictions are given and explanations for their discrepancies are given. Design charts for concentric and eccentric dynamically loaded columns were prepared. A chart for checking long columns for dynamic buckling is presented also.

TN-462 Y-F008-10-108 DASA 13.018
INFLUENCE OF INITIAL DEFORMATION ON THE BENDING OF ARCHES:
A Preliminary Study, D. A. DaDeppo, 19 Feb 63, 30 pp.

This study was part of a long-range program to obtain information which will serve as a guide in developing design methods for underground structures. The results obtained showed that the initial deformation is important in controlling the flexural response of thin arches.

TR-216 Y-F008-10-108 Y-F008-10-402
BLAST LOADING OF SMALL BURIED ARCHES,
J. R. Allgood, C. R. White, R. F. Swalley, and H. L. Gill, 3 Apr 63, 169 pp.

The specific system under study was the semicircular shallow-buried arch which constitutes the Navy's standard personnel shelter. Models of the system were tested in the blast simulator to study the response to static and blast loads, including pressure distribution around the arch, the influence of arching and passive pressure in providing resistance, and the nature of body motions of the arch. Curves showing the form of arching under static and blast loading are given. Buckling and the variation of interface pressure are discussed.

POR-2224 (WT-2224) Operation SUN BEAM (SMALL BOY)
BEHAVIOR OF BURIED MODEL ARCH STRUCTURE, R. F. Swalley, 1963, CONFIDENTIAL.

TR-226 Y-F008-10-102A
BLAST LOADING OF CONCRETE BEAMS REINFORCED WITH HIGH-STRENGTH DEFORMED BARS, W. A. Keenan, 22 Apr 63, 100 pp.

Sixteen simply supported concrete beams reinforced with high-strength deformed bars (91,600 psi yield stress) were subjected to static and dynamic uniformly distributed loads and their behavior observed. Eight beams were conventially reinforced, and eight were partially prestressed. The prime purpose of the prestressing was to limit the cracks and deflections. Both types of beams were subjected to long- and short-duration loads. Several beams were loaded dynamically more than once to determine their resilience and to study the problem of multiple-shot damage. The static and dynamic tests are reported, evaluated, and compared with theory. Equations for the static collapse deflection and the maximum dynamic deflection of a uniformly loaded concrete beam are presented.

TN-520 Y-F008-10-402 DASA 13.018
INVESTIGATION OF A TECHNIQUE FOR PLACING SAND IN THE NCEL BLAST SIMULATOR PIT, J. Nielsen, 6 Jun 63, 12 pp., FOR OFFICIAL USE ONLY.

The testing program consisted of dropping sand through a container having 1/2 inch diameter holes at 1-1/2 inches center-to-center, into a test box having a volume of 2.81 cubic feet. The fall height was varied in order to define the fall-density curve for the particular sand used in the NCEL blast simulator pit. This sand had a uniformity coefficient of 2.7. The results of these tests indicated that a dry density of 104.5 pounds per cubic foot can be obtained by dropping the sand a distance of 36 inches. This is equivalent to a relative density of about 58 percent. The results also indicated that very little segregation occurs using this method and that higher densities can be obtained by vibration after deposition. A concept for the design of a prototype perforated container for use in the NCEL blast simulator pit is given.

TN-486 Y-F008-10-108 DASA 13.018
BODY MOTIONS OF A BURIED ARCH SUBJECTED TO BLAST LOADING, J. R. Allgood and D. A. DaDeppo, 16 Aug 63, 50 pp.

An approximate method was developed for predicting the deflections of the footings of a buried arch subjected to a blast wave traveling along the surface. Results from the theory were compared with measured values from Operation Plumbbob Structure 3.3a. The influence of the dominant parameters is discussed. It is shown that duration of loading is exceedingly important in governing the magnitude of footing deflections. The theory is presented in a form suitable for use in the design office.

TN-561 Y-F008-08-02-108 DASA 13.018
EFFECTIVENESS OF A GRID IN A BLAST SIMULATOR, V. H. Crow, Dec 63, 15 pp.

Test results are presented which demonstrate the effectiveness of a layered grid in increasing the duration of the loading in the NCEL blast simulator. The tests were performed to check the hypothesis that long-duration loads could be obtained in a semi-closed load generation system without developing objectionable reflected pressures. This information was needed to check out a principle of operation for a proposed traveling wave blast simulator. The data demonstrated that it is possible to materially increase the duration for a given energy expenditure and simultaneously prevent the formation of large reflected pressure waves.

7.4 Buildings For Shelter Use

TR-002 H1-300 006
TEMPORARY PROTECTIVE SHELTER: CONSTRUCTION AND PERFORMANCE TESTS, E. O. Donoghue, E. H. Moser, and W. Viessman, 1 Aug 50, 36 pp.

This biological and chemical warfare shelter was prefabricated, portable and readily erected. It was pressurized and was equipped with utilities, air conditioning, and collective protectors.

TM-081 NY 500 002-7
DESIGN, DEVELOPMENT, AND EVALUATION OF A 25-FT BY 48-FT DISASTER SHELTER, W. R. Mason and J. E. Schroeder, 3 Apr 53, 35 pp.

The design and development included a close analysis and revision of the existing criteria and thorough studies of materials. The evaluation included erection studies, weathertightness tests, and structural tests to determine its adequacy for withstanding the specified loads. It was found from these tests that the building was structurally adequate, both simple and rapid to erect, essentially weathertight, and economical in cost and use of materials.

TM-107 NY 300 006-5 NY 300 006-2
CONSTRUCTION, PERFORMANCE, AND BW EVALUATION TESTS OF PORT HUENEME PRESSURIZED BUILDING, JANUARY 1955, E. N. Hellberg, 15 Oct 55, 21 pp.

The abstract is presented on page 5.

WT-1420 Operation Plumbbob
BLAST LOADING AND RESPONSE OF UNDERGROUND CONCRETE ARCH PROTECTIVE STRUCTURE, R. A. Breckenridge and C. K. Wiehle, U. S. Naval Civil Engineering Laboratorys for Headquarters Field Command, Defense Atomic Support Agency, Sandia Base, Albuquerque, New Mexico, 1959, CONFIDENTIAL.

WT-1421 Operation PLUMBBOB
EVALUATION OF BURIED CONDUITS AS PERSONNEL SHELTERS, G. H. Albright, J. C. LeDoux, and R. A. Mitchell, U. S. Naval Civil Engineering Laboratory for Headquarters Field Command, Defense Atomic Support Agency, Sandia Base, Albuquerque, New Mexico, 14 Jul 60, 70 pp.

Twelve large-diameter buried conduit sections of various shapes were tested in the 60-to-149-psi overpressure region of Shot Priscilla to make an empirical determination of the degree of personnel protection afforded by commercially available steel and concrete conduits at depths of burial of 5, 7.5, and 10 feet below grade. Essentially, it was desired to assure that Department of Defense Class I (100-psi and comparable radiations) and Class II (50-psi and comparable radiations) protection is afforded by use of such conduits of various configurations. Measurements were made of free-field overpressure at the ground surface above the structure; pressure inside the structures; acceleration of each structure; dust inside each structure; fragmentary missiles inside the concrete structures; and gamma and neutron radiation dose inside each structure. All buried conduit sections tested provided adequate Class I protection for the conditions under which the conduits were tested. Standard 8-foot concrete sewer pipe withstood 126-psi overpressure without significant damage (minor tension cracks observed); standard 10-gage corrugated-steel 8-foot circular conduit sections withstood 126-psi overpressure without significant damage; and standard 10-gage corrugated-steel cattle-pass conduits withstood 149-psi overpressure without significant damage. Durations of positive pressure were from 206 to 333 Milliseconds.

WT-1422 Operation PLUMBBOB
EVALUATION OF BURIED CORRUGATED-STEEL ARCH STRUCTURES AND ASSOCIATED COMPONENTS, G. H. Albright, E. J. Beck, J. C. LeDoux, and R. A. Mitchell, U. S. Naval Civil Engineering Laboratory for Headquarters Field Command, Defense Atomic Support Agency, Sandia Base, Albuquerque, New Mexico, 28 Feb 61, 111 pp.

Three underground corrugate-steel arch structures covered with 5 feet of earth were subjected to peak overpressures of 60 and 100 psi during Shot Priscilla at the Nevada Test Site. Essentially, it was desired to assure that Department of Defense Class II (50-psi overpressure and comparable radiations) protection is afforded by two types of 25-foot diameter, 180-degree corrugated-metal arches. Free field overpressure was measured at the ground surface above the structures, along with pressure inside each structure, acceleration of the floor slab, arch deflection relative to the floor slab, and gamma and neutron radiation dose inside each structure. Dust was measured inside one structure. All arch structures provided adequate Class II protection for the conditions of the test. One arch structure, reinforced with steel arch ribs, withstood 100-psi overpressure (333-msec positive-phase duration) with no significant damage other than a cracked floor slab. A blast closure valve was tested in the ventilating system of one structure. Operation was satisfactory during the positive-pressure phase, but the valve leaked excessively during the negative-pressure phase.

Prototype pits designed to partially shield emergency power generator sets against blast, missiles, and thermal radiation damage were tested to determine their adequacy. Damage assessment indicated significant but inadequate protection at the overpressures to which the generator sets were exposed.

WT-1626 Operation HARDTACK
RESPONSE OF EARTH-CONFINED FLEXIBLE ARCH STRUCTURES IN HIGH-OVERPRESSURE REGIONS, P. J. Rush and J. C. LeDoux, U. S. Naval Civil Engineering Laboratory for Headquarters Field Command, Defense Atomic Support Agency, Sandia Base, Albuquerque, New Mexico, 1961, SECRET.

TR-191 Y-F011-05-328
DESIGN FOR A CAST-IN-PLACE CONCRETE SHELTER, J. R. Allgood, R. M. Webb, and R. F. Swalley, 13 Dec 62, 105 pp.

The objective of this task was to develop an economical, arch-shaped shelter, utilizing pneumatically-placed mortar, as an alternate to existing standard types. Criteria and plans for a 100-man shotcrete shelter are presented which will provide protection against an overpressure of 100 psi and concomitant effects from nuclear weapons. Shotcrete is recommended because of the economic advantages gained from using a single lightweight form as opposed to the heavy double form required for conventionally placed concrete. An effort was made to provide a balanced and versatile design which may be adapted to the specific needs of various Commands. Methods for the design of the basic structural components of the shelter are given, including a method for estimating the relative displacement between the floor and the foundation when the structure is subjected to blast loading. Simple yet adequate design procedures are given which are suitable for use in the design office.

7.5 Buildings Tested For Advanced Base Use

A large number of buildings have been tested by the Laboratory for the Navy or the Air Force for advanced base use. A few were tested for polar camp use. In most cases, the building was tested for ease of erection; structural adequacy for specified wind and snow loads; packaging and crating; and weathertightness. Since these buildings might be adapted for shelter use, they are listed herein.

TM-038 NY 500 002-2
BUDOCKS-DESIGN 40-FT BY 100-FT PREFABRICATED STEEL UTILITY BUILDING, R. A. Breckenridge and A. B. Bruck, 1 Jan 52, 95 pp.

TM-040 NY 500 002-14
EVALUATION OF A 20-FT BY 48-FT GOTHIC ARCH PREFABRICATED METAL BARRACKS BUILDING, NORTHERN TYPE, MANUFACTURED BY THE J. & B. MANUFACTURING COMPANY, W. R. Mason, J. E. Schroeder, and A. B. Bruck, 26 Mar 52, 25 pp., FOR OFFICIAL USE ONLY.

TM-041 NY 500 002-6
EVALUATION OF A 20-FT BY 48-FT FRAMELESS ARCH, PREFABRICATED METAL BARRACKS BUILDING, NORTHERN TYPE, MANUFACTURED BY THE CENTRAL FARM EQUIPMENT COMPANY, W. R. Mason and A. B. Bruck, 31 Mar 52, 25 pp., FOR OFFICIAL USE ONLY.

TM-050 NY 500 002-9
EVALUATION OF A 40-FT BY 100-FT FRAMELESS STRAIGHT-SIDED PREFABRICATED METAL UTILITY BUILDING, MANUFACTURED BY THE BEHLEN MANUFACTURING COMPANY, W. R. Mason, P. J. Rush, and A. B. Bruck, 1 Apr 52, 21 pp., FOR OFFICIAL USE ONLY.

TM-055 NY 500 002-5
EVALUATION OF A 20-FT BY 48-FT ARCH RIB PREFABRICATED METAL BARRACKS BUILDING, NORTHERN TYPE, MANUFACTURED BY THE STEELCRAFT MANUFACTURING COMPANY, W. R. Mason, P. J. Rush, and A. B. Bruck, 1 Apr 52, 27 pp., FOR OFFICIAL USE ONLY.

TM-039 NY 500 002-11
EVALUATION OF A 40-FT BY 100-FT, ARCH-RIB PREFABRICATED METAL UTILITY BUILDING, MANUFACTURED BY THE PACIFIC IRON AND STEEL COMPANY, LOS ANGELES, CALIFORNIA, W. R. Mason, P. J. Rush, and A. B. Bruck, 1 May 52, 17 pp., FOR OFFICIAL USE ONLY.

TM-057 NY 500 002-15
EVALUATION OF A 20-FT BY 48-FT STRAIGHT-SIDED, GABLED-ROOF, PREFABRICATED METAL BUILDING, NORTHERN TYPE, MANUFACTURED BY POLYNORM BUILDING COMPANY, AMERSFOORT, HOLLAND, W. R. Mason, J. E. Schroeder, and P. J. Rush, 15 May 52, 39 pp., FOR OFFICIAL USE ONLY.

TM-064 NY 500 002-12
EVALUATION OF A 20-FT BY 48-FT, STRAIGHT-SIDED, GABLED-ROOF, PREFABRICATED METAL BUILDING, NORTHERN TYPE, MANUFACTURED BY ARMCO DRAINAGE AND METAL PRODUCTS, INC., MIDDLETOWN, OHIO, W. R. Mason, J. E. Schroeder, and P. J. Rush, 1 Jul 52, 28 pp., FOR OFFICIAL USE ONLY.

TN-143 NY 500 002-23
EVALUATION OF A 20-FT BY 48-FT STRAIGHT-SIDED, GABLED-ROOF, PREFABRICATED, WOODEN EMERGENCY MOBILIZATION UNIT, MANUFACTURED BY THE HOME BUILDING CORPORATION, SEDALIA, MISSOURI, W. R. Mason and J. E. Schroeder, 13 Aug 52, 38 pp., FOR OFFICIAL USE ONLY.

TM-034 NY 500 002-3
EVALUATION OF AN EMERGENCY MOBILIZATION BUILDING MANUFACTURED BY THE GREEN LUMBER COMPANY, LAUREL, MISSISSIPPI, C. H. Mattoon, C. K. Wiehle, and G. B. Schaefer, Oct 52., FOR OFFICIAL USE ONLY.

TN-140 NY 500 002-17
EVALUATION OF A 20-FT BY 48-FT MODIFIED STANDARD ARCH-RIB PREFABRICATED, METAL, NORTHERN TYPE, 5-FT 4-INCH MODULE BUILDING, MANUFACTURED BY THE GREAT LAKES STEEL COMPANY, STRAN-STEEL DIVISION, DETROIT, MICHIGAN, W. R. Mason, P. J. Rush, and A. B. Bruck, 1 Apr 53, 25 pp., FOR OFFICIAL USE ONLY.

TN-141 NY 500 002-21
EVALUATION OF A 20-FT BY 48-FT STRAIGHT-SIDED, SHED-ROOF, PREFABRICATED, WOODEN EMERGENCY MOBILIZATION UNIT, DESIGNED AND FABRICATED BY THE J. B. PIERCE FOUNDATION, RARITAN, NEW JERSEY, W. R. Mason and J. E. Schroeder, 15 Apr 53, 33 pp., FOR OFFICIAL USE ONLY.

TM-079 NY 500 002-22
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